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**USING THE 63358 AND 63361  
45W QUARTZ HALOGEN LAMP  
STANDARDS OF SPECTRAL IRRADIANCE**

Please read these instructions completely before operating this equipment. If there are any questions or problems regarding the use of this equipment, please contact: ORIEL CORPORATION - or - the representative from whom this equipment was purchased.

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**INSTRUCTIONS FOR USING 63358 AND 63361 QUARTZ HALOGEN  
LAMP STANDARDS OF SPECTRAL IRRADIANCE**

**CAUTION**

These lamps operate at a high temperature, such that the quartz envelope is above the flammable point of organic materials. They may thus cause fires and, also, the burning of lint, etc. on the envelope which may result in optical damage to its surface. In no case should the fingers come into contact with the quartz envelope, either hot or cold, as the resulting finger prints will burn into its surface during lamp operation. If finger prints are inadvertently left on the lamp, they should be wiped clean immediately with an alcohol dampened pad before the lamp is turned on.

These lamps produce considerable ultraviolet and infrared radiation. You can detect the infrared by its heating effect and this provides some protective response. You will not normally detect the ultraviolet output that has UVA, UVB and UVC components. Avoid excessive exposure of the eyes or skin to radiation from these or any quartz tungsten halogen lamps. Ultraviolet radiation has been associated with skin cancer and cataract formation. Protective eyewear and gloves are available from Oriel as are UV safety signs.

**INSTRUCTIONS FOR USE**

These instructions cover the use of Oriel 45 W tungsten-filament quartz halogen lamps supplied as standards of spectral irradiance for the wavelength range of 0.25 to 0.9 and 0.25 to 2.5 microns.

The lamps produce the calibration irradiance values at 50 cm from the lamp over an approximately 5 cm diameter field normal to the optical axis of the lamp.

**Type Of Lamp**

The lamps employed (Figure 1) are specially selected commercial lamps having a tungsten filament enclosed in a clear quartz envelope containing a small amount of a halogen gas. The lamps supplied are selected for spectral and electrical characteristics, and to a lesser extent, for cosmetics. Each lamp undergoes a burn-in and test schedule. Small white spots on the lamp are normal and do not affect the operation or calibration.

## Calibration Procedure at Oriel

We mount each lamp in the manner described below and measure the spectral irradiance by correlation to the spectral irradiance of a NIST calibrated 1 kW lamp. The NIST standards are calibrated by comparison with the spectral output of a blackbody operated at the gold point.

## Spectroradiometer Checks

We regularly check the wavelength fidelity of our spectroradiometers using our Pencil Style low pressure mercury lamps. We check linearity using a modification of the two beam technique. We reduce the importance of linearity by operating the kW standards at 2 m from the spectroradiometer, and operating the 45 W lamps at the prescribed 50 cm. We find that stray radiation can become a problem for high precision measurements with our single grating- based radiometers below 300 nm. For our scanning systems, we overcome this by using our double monochromator or a solar blind detector. We use bandlimiting filters to reduce stray light in our diode array based radiometers.

## MOUNTING OF THE LAMP

### Do not use a lamp housing

The lamp has been calibrated while operating in an open environment. Do not use a lamp housing as this will change the operating conditions of the lamp, and invalidate the calibration; elimination of internal reflections in the lamp housing usually proves impossible.

These standards require no auxiliary optics. If any are employed proper correction must be made for their optical characteristics. The lamp is simply placed at a measured distance from the detector or spectrometer slit. If a distance other than 50 centimeters is used, the inverse-square law may be used to calculate the spectral irradiance. (The inverse-square law should not, however, be used for distances shorter than about 30 centimeters).

### Identify the Optical Axis

You should first make measurements to determine the optical axis of your system. This will be the line through the center of and normal to the target to be irradiated. In our calibration procedure this is the input axis of the spectroradiometer used for calibration. A small HeNe laser is extremely useful for marking the system axis for precise location of the lamp, and is highly recommended for any set-up requiring frequent insertion and removal of the lamp.

You should mount the lamp vertically in a 63366 Lamp Mount and with the pip on the envelope away from the target. (Figure 1) This holder accepts Oriel bench rods so you can mount it and adjust the height by using Oriel rods and rod holders.

Measurements of distance (from lamp filament) are made along a horizontal axis passing through the center of the lamp filament. Accurate placement is important; a 2.5 mm error results in a 1 % error in calibration.

### Avoid Secondary Reflections

If you mount your equipment on an optical table or laboratory bench then cover the surface with material such as black velvet to prevent secondary (specular) reflections of radiation from the lamp to the target zone. Similarly cover any adjacent vertical surfaces that could lead to the same type of problem.

You should place a black shield at a distance of about 4 feet to the rear of the lamp to intercept stray radiant flux along the radiometric axis and adequate shielding should be provided to intercept stray flux from other directions. (Figure 2). You can construct a shield of aluminum material, wood or cardboard. You should paint it with a good flat black paint such as Krylon high temperature (stove) paint. If you do not construct a rear shield, then reflections from laboratory walls, laboratory equipment or from people in the laboratory can affect the irradiance of the target and change it from the calibration value.

You can also place a black shield as shown in front of the lamp to prevent heating the equipment surrounding the target area unnecessarily. This shield should be carefully placed along the optical axis. You can find the minimum dimensions of the aperture by "tracing rays" from the extremes of the lamp envelope to the target extremes. Place this shield far enough away from the lamp to avoid distorting the lamp's temperature environment or heating the shield so it becomes a secondary radiator.

### Caution About Humid Environment

If there is excessive water vapor in the laboratory atmosphere, then the irradiance calibration data will not be valid at the wavelengths of water-vapor absorption bands (particularly at  $1.4\ \mu\text{m}$ ). In the original calibrations the comparisons of the lamps with the NIST traceable standards were performed so as to eliminate the effect of water-vapor absorption. If you are in doubt about the significance of these effects, and are using the lamp for calibration of a spectroradiometer, then you can check by operating the lamp at for example 1 m and then at 0.5 m from the instrument. Scans around  $1.4\ \mu\text{m}$  should differ only by 4 (inverse square law scaling). With significant water vapor they will differ slightly at the water absorption peaks.

## IRRADIANCE DATA FOR THE LAMPS

### Calibration Units

Values of spectral irradiance for these lamps (at the calibration current) are tabulated as a function of wavelength in microwatts (per square centimeter-nanometer) at a distance of 50 centimeters from the center of the lamp to the receiver. Values of spectral irradiance for wavelength intervals other than one nanometer, say  $x$  nanometers, may be found by multiplying the tabulated values by  $x$ .

For example, an irradiance of  $6 \mu\text{W nm}^{-1} \text{cm}^{-2}$  at 550 nm, corresponds to an irradiance of  $6000 \mu\text{W nm}^{-1} \text{cm}^{-2}$  at 550 nm, as there are 1000 nm in 1  $\mu\text{m}$ .

### \* \* \* CAUTION \* \* \*

Many meters (including the one on the 68830) are not sufficiently accurate for setting lamp current. The current must be set very accurately (preferably within 0.2%) to reproduce the calibration values. A 1% change in current results in a 9% inaccuracy in the ultraviolet irradiance though in a much smaller discrepancy in the visible and infrared.

We recommend the use of a precision current shunt, such as the Oriel 68832, and an accurate digital voltmeter.

### Interpolation

Original NIST traceable calibration data is available only at a number of discrete wavelengths. We list the irradiance at these wavelengths in your calibration table. [See Figure 4] We interpolate between these wavelengths to determine the irradiance at other wavelengths and have recorded no spectral anomalies. This suggests that a smooth curve through the points will give valid irradiance data at other wavelengths. Figure 3 shows a typical curve.

Saunders of NIST provided a mathematical model for the irradiance of a tungsten halogen lamp of this type that can be used for interpolation after least squares fitting:

$$\ln[E_w \times w^5] = a - b/w$$

where  $w$  is the wavelength and  $E_w$  the irradiance at wavelength  $w$ . You will obtain an even better fit if you split the spectrum in two; from 250-400 nm and from 350 to 1600 nm.



## USE OF THE LAMP

### Lamp Calibration Current

The lamp must be operated at the calibration current to produce the calibration irradiance. The ORIEL Model 68830 Radiometric Power Supply provides the lamp with a highly stable DC current. You can preset and read the current to  $\pm 2\%$

### Use Of The Lamp To Determine The Irradiance Produced By An Unknown Source

In measurements where two sources (a standard source and a test source) are being compared by the direct substitution method, (slit widths kept unchanged, use of the same detector) no knowledge of the spectral transmittance of the spectrometer, nor of the spectral sensitivity of the detector is required. It is necessary, however, to make sure that the entrance slit of the spectrometer is equivalently filled with radiant flux, both from the standard and from the test source. Filling the input fully and uniformly is the most efficient approach. If the standard and test source differ in geometrical shape, you should ensure that the instrument transmittance and detector response are not adversely affected by this.

Many detectors are highly variable in sensitivity over their surface area and may require diffusion of radiant flux over their surface to insure accurate radiant energy evaluations. We use either transmitting diffusers or integrating spheres on the input to our spectroradiometers, depending on the accuracy we seek and the signal level. Oriel 4 inch Integrating Spheres usually reduce the direct signal by about 500 while a factor of 100 is a rule of thumb for transmitting diffusers.

Polarization provides an additional complication. These lamps may be slightly (to 5% in the worst case) polarized and the "unknown source" may be strongly polarized. The spectral responsivity of many spectroradiometers is sensitive to polarization because the efficiency of diffraction gratings is polarization dependent. Use an integrating sphere to remove any adverse effects of polarization.

### Prolonging The Life Of The Standard

These standards of spectral irradiance are expensive laboratory equipment and it is suggested that they be operated sparingly and with care in order to prolong or reach their useful life of ca. 500 hours. They should be turned on and off at reduced current and great care should be taken so that at no time does the current appreciably exceed their rated current.

We highly recommend a "use log" and the establishment and strict adherence to a routine for replacement or re-calibration.

### Use More Than One Calibrated Lamp For Highest Confidence

Following NIST, we recommend that for serious calibration work, you have a minimum of three calibrated lamps and regularly inter-compare these, returning the lamps one at a time to Oriel for re-calibration.

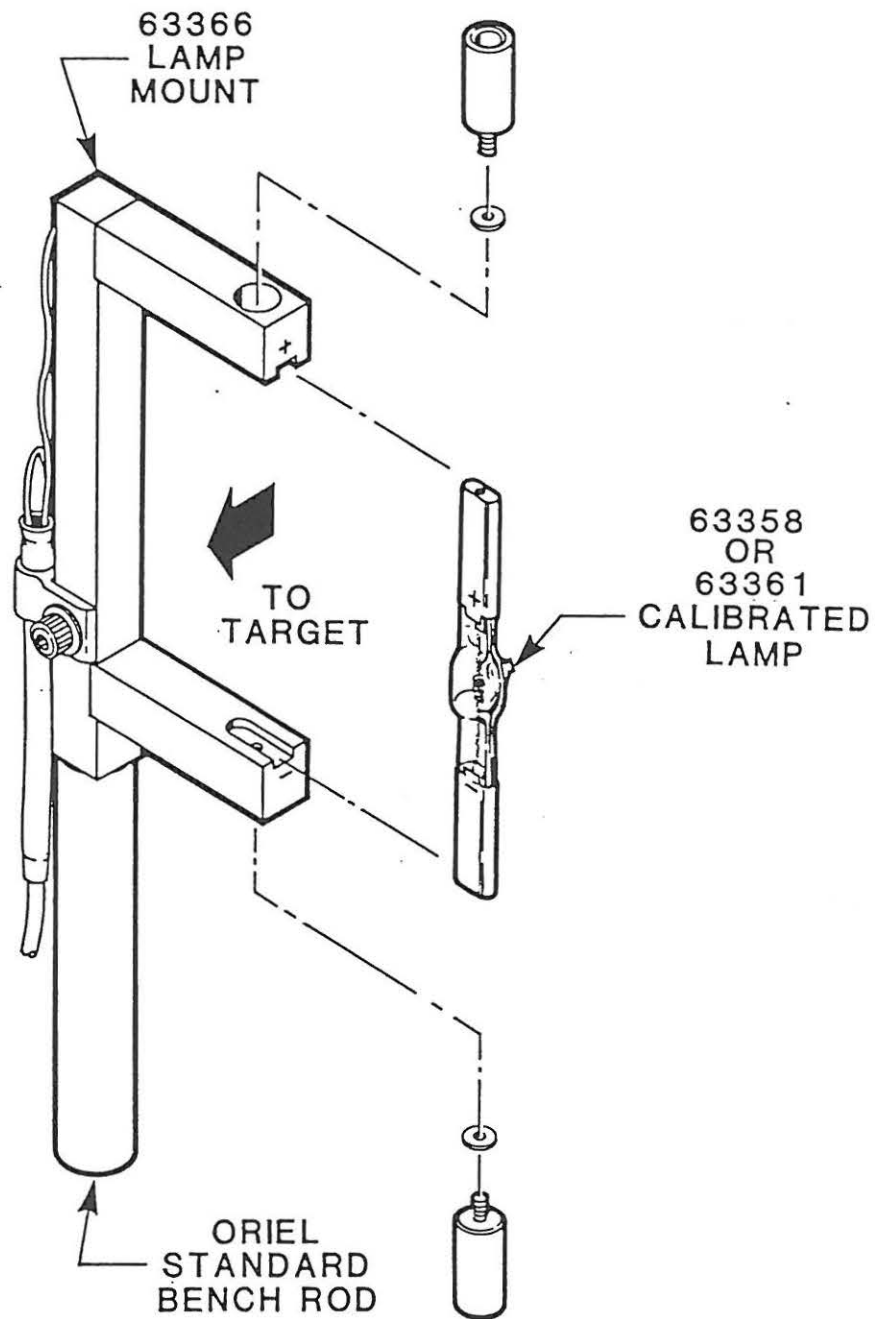


Figure 1

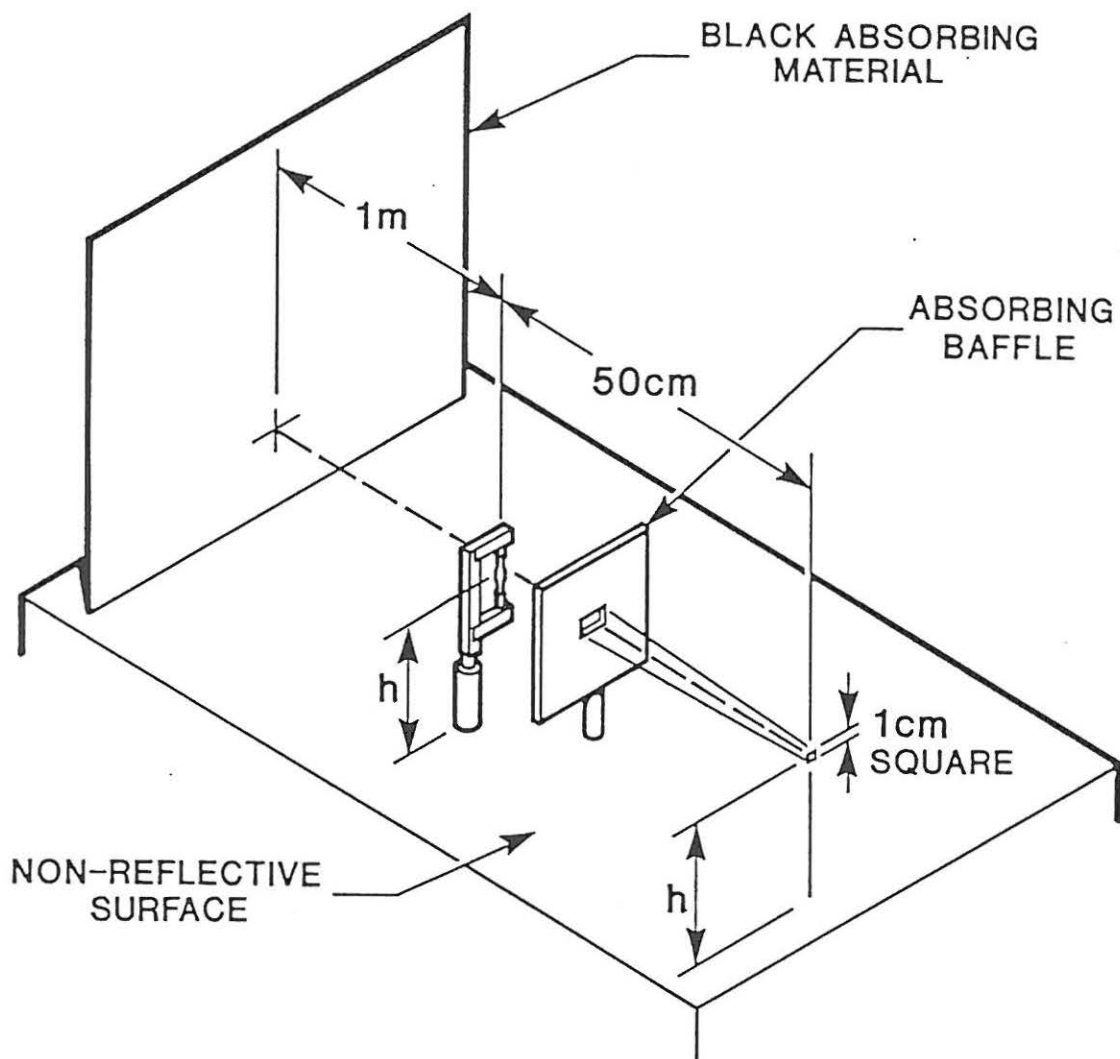


Figure 2  
Lamp Mounting to Minimize Secondary Reflections

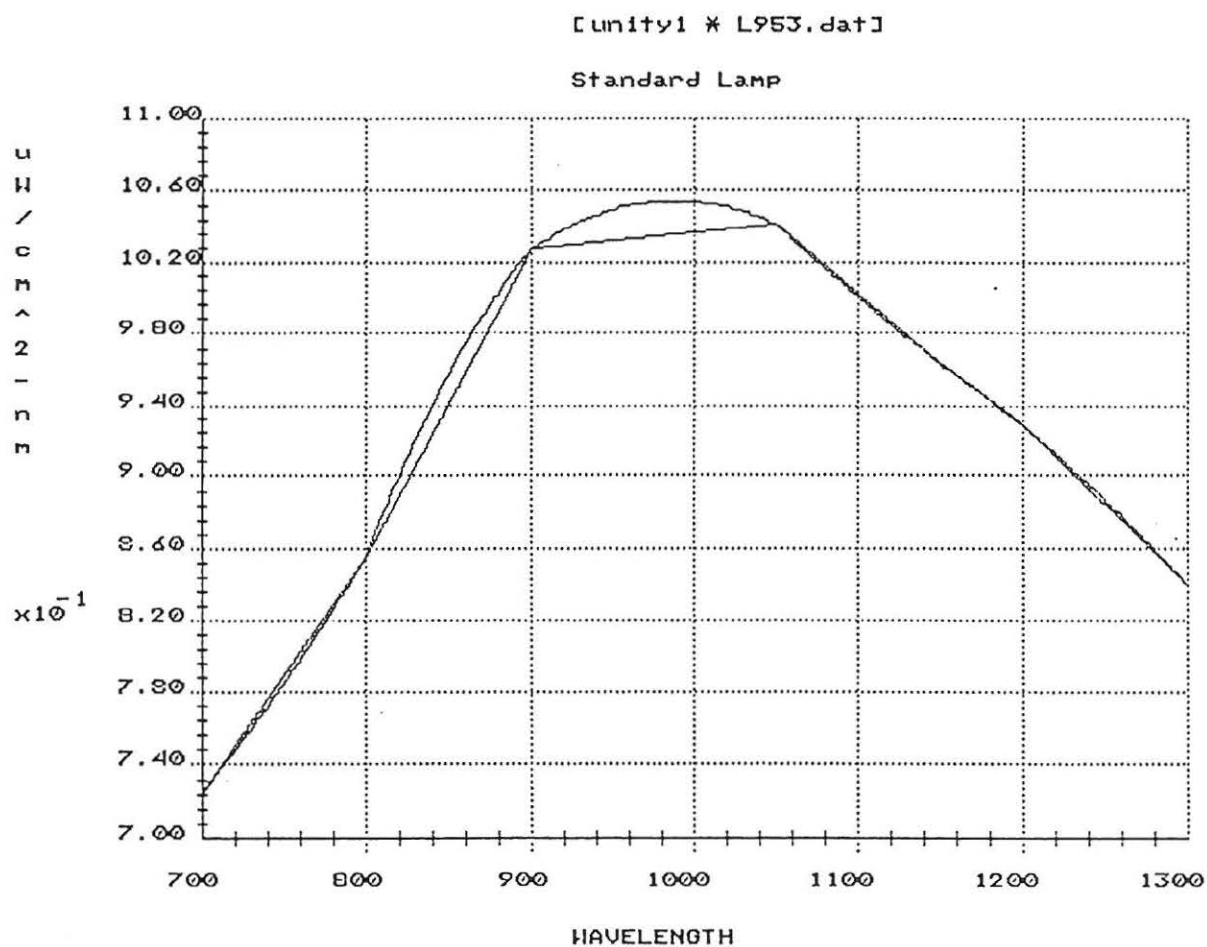


Figure 3  
A Portion of a Typical Standard Lamp Irradiance Curve Showing Interpolation Between the Tabulated Points

# CALIBRATION RESULTS

Wattage : 45  
Model No. : 63358  
Serial No. :  
Spectral Range : 250 - 2500nm  
Lamp Current : 6.50 amps  
Date :

<u>Wavelength (nm)</u>	<u>Spectral Irradiance (<math>\mu\text{W}/\text{cm}^2\text{-nm}</math>)</u>
250.00	6.419e-04
260.00	1.155e-03
270.00	1.913e-03
280.00	2.920e-03
290.00	4.184e-03
300.00	5.893e-03
310.00	8.503e-03
320.00	1.091e-02
330.00	1.434e-02
340.00	1.883e-02
350.00	2.432e-02
400.00	6.918e-02
450.00	1.473e-01
500.00	2.522e-01
550.00	4.005e-01
600.00	4.957e-01
650.00	6.115e-01
700.00	7.243e-01
800.00	8.551e-01
900.00	1.027e+00
1050.00	1.041e+00
1150.00	9.634e-01
1200.00	9.283e-01
1300.00	8.397e-01
1550.00	5.017e-01
1600.00	4.385e-01
1700.00	3.595e-01
1800.00	2.943e-01
1900.00	2.542e-01
2000.00	2.256e-01
2100.00	1.977e-01
2200.00	1.717e-01
2300.00	1.504e-01
2400.00	1.297e-01
2500.00	1.107e-01

Figure 4 Typical Calibration Table

## WARRANTY AND RETURNS

### WARRANTY

Oriel Corporation warrants that all goods described in this manual (except consumables such as lamps, bulbs, filters, ellipses, etc.) shall be free from defects in material and workmanship. Such defects must become apparent within the following period:

1. All products described here, except spare parts: one (1) year or 3000 hours of operation, whichever comes first, after delivery of the goods to buyer.
2. Spare parts: ninety (90) days after delivery of goods to buyer.

Oriel Corporation's liability under this warranty is limited to the adjustment, repair and/or replacement of the defective part(s). During the above listed warranty period, Oriel Corporation shall provide all materials to accomplish the repaired adjustment, repair or replacement. Oriel Corporation shall provide the labor required during the above listed warranty period to adjust, repair and/or replace the defective goods at no cost to the buyer ONLY IF the defective goods are returned, freight prepaid, to an Oriel Corporation designated facility. If goods are not returned to Oriel Corporation, and user chooses to have repairs made at their premises, Oriel Corporation shall provide labor for field adjustment, repair and/or replacement at prevailing rates for field service, on a portal-to-portal basis.

Oriel Corporation shall be relieved of all obligations and liability under this warranty if:

1. The user operates the device with any accessory, equipment or part not specifically approved or manufactured or specified by Oriel Corporation unless buyer furnishes reasonable evidence that such installations were not a cause of the defect. This provision shall not apply to any accessory, equipment or part which does not affect the safe operation of the device.
2. The goods are not operated or maintained in accordance with Oriel's instructions and specifications.
3. The goods have been repaired, altered or modified by other than Oriel authorized personnel.
4. Buyer does not return the defective goods, freight prepaid, to Oriel repair facility within the applicable warranty period.

IT IS EXPRESSLY AGREED THAT THIS WARRANTY SHALL REPLACE ALL WARRANTIES OF FITNESS AND MERCHANTABILITY. BUYER HEREBY WAIVES ALL OTHER WARRANTIES, GUARANTIES, CONDITIONS OR LIABILITIES, EXPRESSED OR IMPLIED, ARISING BY LAW OR OTHERWISE, WHETHER OR NOT OCCASIONED BY ORIEL'S NEGLIGENCE.

This warranty shall not be extended, altered or varied except by a written document signed by both parties. If any portion of this agreement is invalidated, the remainder of the agreement shall remain in full force and effect.

### CONSEQUENTIAL DAMAGES -

Oriel Corporation shall not be responsible for consequential damages resulting from misfunctions or malfunctions of the goods described in this manual. Oriel's total responsibility is limited to repairing or replacing the malfunctioning or malfunctioning goods under the terms and conditions of the above described warranty.

### INSURANCE -

Persons receiving goods for demonstrations, demo loan, temporary use or in any manner in which title is not transferred from Oriel, shall assume full responsibility for any and all damage while in their care, custody and control. If damage occurs, unrelated to the proper and warranted use and performance of the goods, recipient of the goods accepts full responsibility for restoring the goods to their condition upon original delivery, and for assuming all costs and charges.

### RETURNS

Before returning equipment to Oriel for repair, please call the Customer Service Department at (203) 377-8282. Have your purchase order number available before calling Oriel. The Customer Service Representative will give you a Return Material Authorization number (RMA). Having an RMA will shorten the time required for the repair, because it ensures that your equipment will be properly processed. Write the RMA on the returned equipment's box. Equipment returned without a RMA may be rejected by the Oriel Receiving Department. Equipment returned under warranty will be returned with no charge for the repair or shipping. Oriel will notify you of repairs not covered by warranty, with the cost of the repair, before starting the work.

Please return equipment in the original (or equivalent) packaging. You will be responsible for damage incurred from inadequate packaging, if the original packaging is not used.

Include the cables, connector caps and antistatic materials sent and/or used with the equipment, so that Oriel can verify correct operation of these accessories.

**REPORT OF CALIBRATION**  
**of One Standard of Spectral Irradiance(250-2500nm)**

Oriel Part # 63358      Serial Number

Supplied to: FLORIDA STATE UNIV.

1      Material

One 45 watt, quartz halogen, tungsten coiled coil filament lamp supplied by Oriel Corporation with designation 9-064

2      Calibration Procedures

The lamp was pre-treated and calibrated using custom designed equipment in Oriel's calibration facility and modeled on the equipment and procedures described in NBS Special Publication 250-20. The preparation and operation of the modified FEL lamp are described in "Type FEL Lamp Standards of Spectral Irradiance -1986"

3.      Calibration Reference

The lamp used as reference was # 3-062. This lamp was calibrated using NIST reference standards: F-211,EN-76

4.      Results

The spectral irradiance produced by Standard 9-064 at a distance of 0.5 m when operated at the calibration current are tabulated on the attached sheet.

Tested By:

Checked By:

Date:

4/22/95



**CALIBRATION RESULTS**

Wattage : 45  
Model No. : 63358  
Serial No. : 9-064  
Spectral Range : 250-2500 nm  
Lamp Current : 6.50 amps  
Date : April 22, 1995

<b><u>Wavelength (nm)</u></b>	<b><u>Spectral Irradiance (uW/cm<sup>2</sup>-nm)</u></b>
250.0	2.600E-4
260.0	5.400E-4
270.0	8.800E-4
280.0	1.510E-3
290.0	2.320E-3
300.0	3.600E-3
310.0	5.190E-3
320.0	7.310E-3
330.0	1.037E-2
340.0	1.351E-2
350.0	1.839E-2
400.0	5.561E-2
450.0	1.212E-1
500.0	2.167E-1
555.0	3.506E-1
600.0	4.523E-1
654.6	5.817E-1
700.0	6.796E-1
800.0	8.518E-1
900.0	9.250E-1
1050.0	9.255E-1
1150.0	8.748E-1
1200.0	8.415E-1
1300.0	7.691E-1
1550.0	5.708E-1
1600.0	5.383E-1
1700.0	4.704E-1
2000.0	3.180E-1
2100.0	2.825E-1
2300.0	2.171E-1
2400.0	1.906E-1
2500.0	1.670E-1

## **OPERATION OF THE IRRADIANCE STANDARD**

### **Safety Considerations**

There are three hazards associated with operation of this lamp.

1. Ultraviolet Radiation
2. Heat
3. Electrical

#### **1. Ultraviolet radiation**

These lamps emit low levels of ultraviolet radiation, UVA, UVB and UVC. Since these are potentially hazardous to the eyes and the skin, we recommend that you wear UV goggles and limit exposure of the skin. You will find a discussion on ultraviolet safety on page 1-191 of Oriel Volume II catalog. This page also shows the current recommended Threshold Limit Values for occupational exposure to ultraviolet. You should use the irradiance data and the radiation square law to estimate whether UV will be a problem. Obviously it depends how close you work to the lamp, how long you operate the lamp etc. UV goggles and glasses are available from Oriel. To limit skin exposure in an open laboratory environment we recommend you fabricate shields to enclose the lamp. These should be large enough (at least 0.5 m from the lamp) to ensure the lamp is effectively in the open air. Small enclosures will change the thermal operating conditions of the lamp and hence the calibration.

#### **2. Heat**

The surface of the lamp is hot enough to burn skin or ignite combustible materials. Additionally, dark combustible materials close to the lamp may ignite.

#### **3. Electrical hazard**

The lamp operates at ca. 7 V and 6.35 A. While these are not usually considered hazardous levels we recommend you post appropriate warning signs since "live terminals" are exposed.

### **Mounting the lamp**

The irradiance standard is intended for vertical operation in the open air. The lamp should be held in an Oriel Model 63366 Lamp Mount or similar. All calibration and life data available refers to this form of operation. Different types of operation, for example horizontal operation or operation in an enclosure may result in different irradiation and shorten the useful life.

## Power source

The lamps require a source of well regulated constant current such as the Oriel 68830, The current source needs to be accurately calibrated to reproduce the calibration current. Deviations from the calibration value result in changes in the irradiance produced with the highest discrepancies in the ultraviolet region of the spectrum.

## LAMP LIFE

Studies at NIST of the type of lamp used show different drift rates with time for lamps tested. While the drift (in % per 100 operating hours) was worst at 250 nm, the values (at 250 nm) for the lamps tested varied from 0.5 % to 4.8 %. We reproduce the NIST data for your information.

Wavelength (nm)	Lamp #			
	1	2	3	4
250	0.5	4.3	4.0	4.8
350	0.45	3.4	2.9	3.35
450	0.4	2.9	2.3	2.55
555	0.4	2.55	1.9	2.0
654.6	0.4	2.35	1.6	1.65
800	0.4	2.1	1.35	1.3
1300	0.35	1.7	0.8	0.65
1600	0.35	1.6	0.75	0.5

Please note that these drift rates are for constant operation of the lamp. We expect worse data when the lamp is run for short periods as the filament is subjected to thermal shock each time the lamp is started. Oriel DC power supplies for these lamps have a "soft start" feature to mitigate this problem. Gradual increase to the operating current over a period of some minutes should allow you to approach the drift rates above when you operate the standard lamp for shortened periods.

## NIST Results

Results are provided at NIST specified wavelength data points. Estimated Transfer Uncertainty ( $3\delta$ ) is as follows. The NIST Uncertainty of Reported Values for the test lamp with respect to SI units are listed for information.

Wavelength (nm):	250	350	654.6	900	1300	1600	2000	2400
NIST Uncertainty	2.23	1.35	1.01	1.34	1.42	1.89	3.29	6.51
Oriel Transfer Uncertainty	2	1.5	1	3	3	3	5	5
Total	3	2	1.4	3.3	3.4	3.6	6	8.2

(Quadrature sum)

For irradiance data at wavelengths other than those listed, follow the curve fitting procedure described in NBS Special Publication 250-20, page 25.